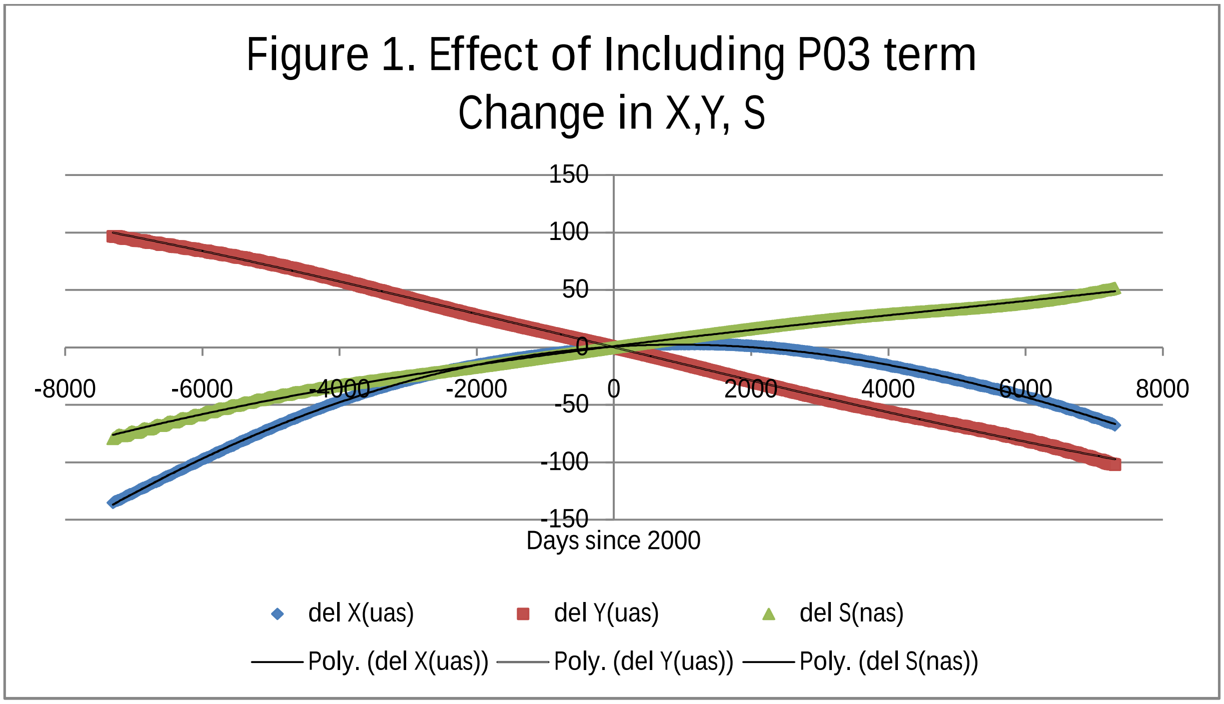
To: IVS Community
From: John Gipson
Date: October 10, 2008
Re: Including P03 term in Nutation

One of the action items from the IVS-Analysis workshop in St. Petersburg was to figure out how to include the P03 term in the *calc-solve* analysis package.

The actual effect of this term has been incorporated into the SOFA routines which calculate (X,Y, S), and the most straightforward way of making the change would be modify *solve.* The major problem with this is that it would require re-*calcing* all of the databases.

All alternative is to do this in *solve.* Essentially *calc* would calculate (X,Y,S) using the 2000 models, and then *solve* would calculate and apply corrections to them. Computing this difference in *solve* is straightforward in principle: First, calculate the (X,Y,S) terms using the 2006 SOFA routines; Then, calculate the same quantities using the 2000 routines; Last, compute the difference. This difference for the period 1980-2020 is plotted in Figure 1 below. The X axis is days since 2000. The Y axis is in micro-arcseconds for X and Y, and in nano-arcseconds for S. The difference between the two nutation models is fairly small and slowly varying. The last means that we don't have to consider the effect on rates.

A minor problem with using the SOFA routines in *calc/solve* is that the SOFA routines are written in Fortran 77, while *calc/solve* is written in Fortran 90. Although the conversion from Fortran 77 to Fortran90 is straightforward in principle, it would still take many days to do it and to verify that there are no problems.



An alternative is to find an approximation for the difference. Also included in Figure 1 is a 3rd degree polynomial fit to the differences. As is visually apparent, this approximation is quite good. Figure 2 below plots the residuals from the polynomial fit. Note that with the exception of the very end, the residuals over the entire 40 year period are ~ 2 micro-arcseconds in X and Y, and 3 nano-arcseconds in S. At the current time (~day 3000) are under 1 micro-arcseconds in X and Y, and 2 nano-arcseconds in S.

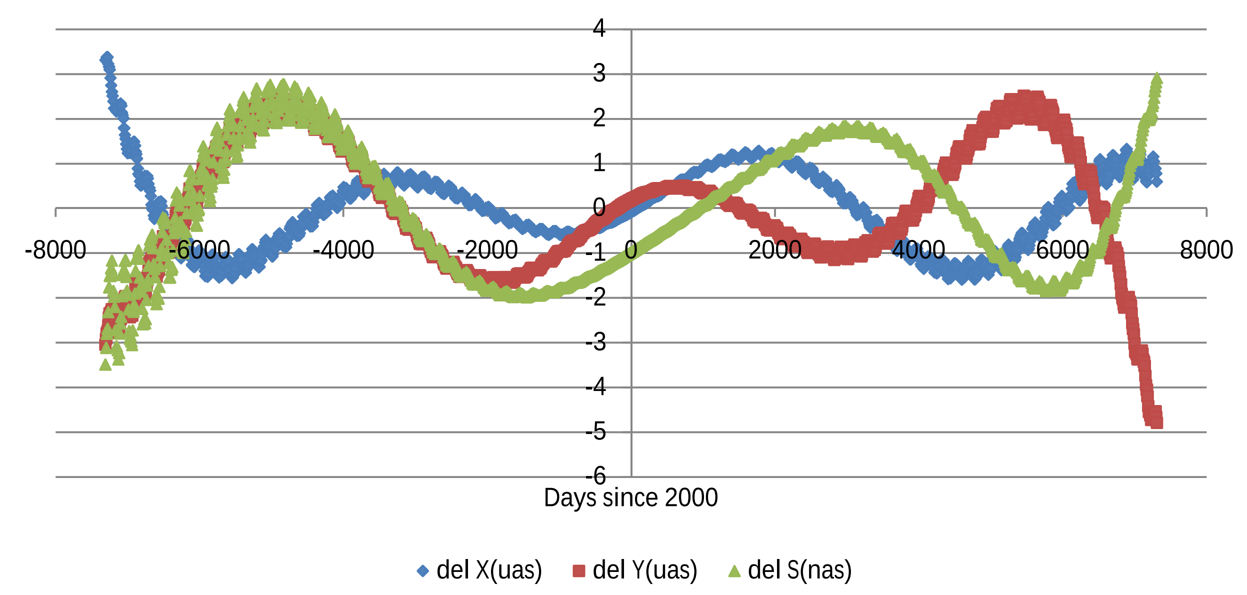


Figure 2. Residuals from 3rd degree polynomial fit

The coefficients to the polynomial are given below.

	X	Y	S
0	9.5963519730E-02	3.5463307490E-03	9.8552498981E-01
1	3.7602787453E-03	-1.4533459856E-02	7.5005751665E-03
2	-1.9403375991E-06	2.2060365633E-08	-2.7451004156E-07
3	1.9505082627E-11	1.9581601044E-11	1.9659180847E-11

I investigated the effect of using both lower and higher degree polynomials. A first degree polynomial does not capture the curvature. A second degree polynomial does almost as well at fitting the data. Fourth and fifth degree polynomials offer negligible improvement.

Future Plans

At Goddard we plan on including the P03 in the analysis by modifying *solve* to compute the differences in (X,Y,S) once per session, and add these differences to the results from *calc*, which does not use this term. We will compute this difference using either the SOFA routines, or the cubic approximation above.